Rezaeian, Maryam and Wynn, Martin G ORCID: 0000-0001-7619-6079 (2021) The Impact of Cloud Computing on the IT Support Function. In: Handbook of Research on Digital Transformation, Industry Use Cases, and the Impact of Disruptive Technologies. Advances in E-Business Research Book Series . IGI-Global, Hershey PA, pp. 1-17. ISBN 9781799877127

Official URL: http://dx.doi.org/10.4018/978-1-7998-7712-7.ch001
DOI: http://dx.doi.org/10.4018/978-1-7998-7712-7.ch001
EPrint URI: https://eprints.glos.ac.uk/id/eprint/10496

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Chapter 1
The Impact of Cloud Computing on the IT Support Function:
A Case Study From Higher Education

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ABSTRACT

The development of digital technologies has opened up new opportunities for e-learning in higher education. These technologies include cloud computing, which promises a scalable and reliable computing environment for both staff and students. This has not only changed the teaching, learning, and research environment, but also affected the way IT support services must now operate in the university sector. This chapter investigates the adoption of cloud computing in higher education through a case study of a major UK university and focuses on how this has affected the IT support function. The benefits and challenges of implementing cloud computing are explored, using questionnaires and interviews to generate data and analysis. The chapter concludes that cloud migration is a complex undertaking requiring a robust strategy that pays due attention to a wide range of issues, notably security concerns and the need for reskilling and the development of new support roles.

INTRODUCTION

The provision of high-quality teaching and learning is a key objective in most educational institutions, and cloud computing supports universities in improving their operations in both the academic and professional service arenas. Cloud computing has been defined as a "model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with

DOI: 10.4018/978-1-7998-7712-7.ch001

minimal management effort or service provider interaction" (Mell & Grance, 2011, p.3). It has not only changed the way we access IT services, but it is arguably also more efficient and cost effective (Sanchati & Kulkarni, 2011). Cloud computing provides a more agile technical environment and increases access to remote systems over the internet.

Based on a detailed case study, this chapter investigates the adoption of cloud computing in higher education and how it is impacting IT support services. In the following section, recent literature is reviewed to establish some of the fundamental issues involved in cloud migration, support and maintenance. The research methodology is then outlined, focusing on a case study of a major UK university, for which the pseudonym "BCU" is used. The findings from the case study interviews are then presented, and emergent issues are discussed. The final section summarises the main findings and briefly discusses some possible future research directions in this field.

RELEVANT LITERATURE

Sultan (2010) described cloud computing as large data centres and server farms, which provide on-demand resources and services over the internet, thereby providing access to applications and data without reference to the underlying hosting infrastructure. Such data centres are monitored and maintained by different service providers such as Google, Amazon, and Microsoft. The growth of cloud computing has been significant in the past decade. Computing Research (2016) concluded "the meteoric rate of growth in the use of cloud services, along with the sheer number of services which now depend upon it, mean that cloud has moved from being used selectively for only non-critical applications and workloads, to being a mainstream proposition for organisations of all sizes" (p.3). More specifically, Cloudian (2020) observe, "technology is shaping higher education. From applications that optimize data access, to online instruction videos, to the use of supercomputers for advanced research and analytics, institutions are using technology to expand knowledge, enhance learning and drive student success" (p. 1). In similar vein, Iftode (2020) recently concluded that "higher education institutions are particularly affected by the continuously evolving technology, and the need to create a synergy between technologies, teaching/learning methods, students' preferences and needs" (p.236). However, due to the nature of higher education, each department or faculty has historically generated and stored its own data with particular requirements for access and update – creating the data silos that bedeviled the introduction of integrated corporate systems in the private sector in the last century. This presents particular problems for migration of such systems to the cloud and their on-going support and maintenance.

Recent research has highlighted the changing requirements for university technology support, notably in the area of cybersecurity (Rezaeian & Wynn, 2019). Cloud computing has been widely adopted by most higher education institutes to some degree, and this has presented support teams with new challenges, not least because of the variety of services available in the cloud. There are different types of delivery services, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), available from a range of service providers (Table 1). These include some of the so-called "hyperscalers" (Leopold, 2017, April 12), notably Amazon, Microsoft and Google. With IaaS, the provider manages just the servers, storage, networking and virtual machines in the cloud. PaaS, widely deployed in higher education, goes one step further, with the provider making available a development environment that enables users to create and run custom built applications supported by the provider, using products such as Microsoft Azure. The management of applications and data, however, remain the

Table 1. Cloud IaaS/PaaS global market share

Provider	Market Share (%)
Amazon Web Services (AWS)	33
Microsoft Azure	15
Google Cloud Platform (GCP)	8
Alibaba	4
IBM	3
Oracle	1
SAP	1
Workday	1
Salesforce	1
Other	33

Source: Delta (2020, p.2)

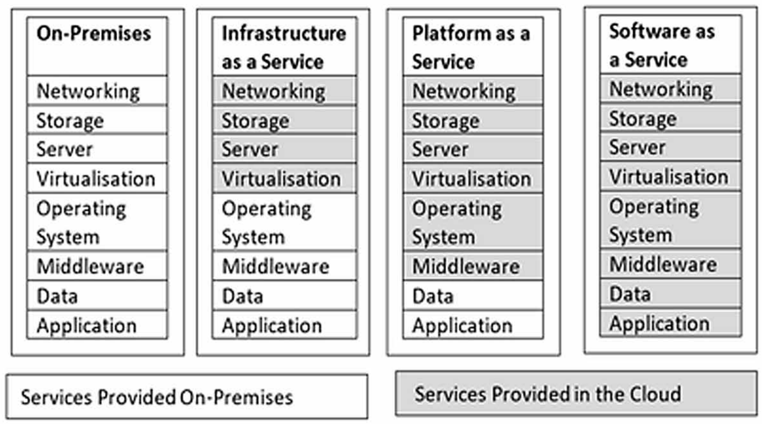
responsibility of the end-user, not the provider. In SaaS, the applications are run on the provider's cloud service, and both applications and data are managed by the provider. However, this option is mainly designed for packaged business software, and there is no development environment for the users. This is the most extreme option for cloud computing, being at the other end of the spectrum to on-premises ("on-prem") computing, where everything is run and managed in-house (Figure 1). Some authors have suggested further nuances on this three-way classification of cloud services. White (2020), for example, identifies Data as a Service (DaaS) as being a fourth cloud service, which he equates to "insight as a service" (para. 9).

In addition, there are different deployment models - private cloud, public cloud and hybrid cloud.

In private cloud, the cloud infrastructure is for the exclusive use of one organization. It may exist on premises or off-premises, and may be owned and operated by a third-party provider. Public cloud, on the other hand, as the name suggests, can be used by any subscriber. It exists on the premises of the cloud provider, but may be owned and operated by other organisations as well. Hybrid cloud involves a combination of private and public infrastructures that are distinct but adhere to common standards that facilitate data and application portability between the two environments (Dresner Advisory Services LLC, 2020). UKCloud (2020) identified five main concerns for organisations considering moving to the cloud - security, compatibility, skills, budgeting, and speciality. Rather similarly, in a study of cloud computing at Benghazi University, Elnajar et al. (2019) found that the main challenges centered on "data insecurity, privacy concerns, and fear of downsizing staff positions, reliability challenges and resistance to change in modern technologies in education, and infrastructure problems in the country" (p.7). It is clear that moving systems to the cloud presents a range of challenges and new issues for university technology support functions.

Nevertheless, there are also a number of significant benefits. In a survey of 147 IT professionals, Bytes (2020), reported that almost 90% cited flexibility as a major reason for cloud migration, followed by scalability, security and cost savings. A number of technology providers not surprisingly highlight the positives in cloud migration. Citrix (2020), for example, cite "faster time to value", "deployment flexibility", and "simplified management, security, and business continuity" as key benefits, and conclude "the shift to virtual apps and desktops service is more than just a licensing upgrade: virtual apps and

Figure 1. Cloud services delivery options
(based on Goldberg, 2018)



desktops service provides a superior economic and strategic alternative to purchasing and maintaining the infrastructure on-premises" (p.15). In similar vein, Avaya (2020, pp. 2-5) claim that cloud computing provides a range of benefits: it unifies communications across your organisation; simplifies multi-location management; flexes when your business flexes; reduces infrastructure management headaches and costs; connects mobile and remote workers; provides instant access to the latest features; and allows greater overall simplicity.

More specifically, Perry (2019) identifies "three typical drivers for undertaking the effort of migrating an application to the cloud, which can also affect your choice of a migration strategy." First "application teams are moving to the cloud to increase their agility, as a cloud-based model enables the provisioning of machines within hours or even minutes." Second, the ability to scale-up the use of infrastructure: "organizations are seeking an alternative where they do not need to plan or invest ahead of time for such increases in demand, and the cloud offers this potential." Third, the manageability of trialling new technologies: "cloud computing provides the option of pay-as-you-go, so organizations can test, develop, and experiment with these innovative technologies" (para. 3).

The cloud has also introduced a different environment for software development, programming and deployment, with a new set of tools and concepts. In "serverless" computing, the cloud provider makes machine resources available as required by the end-user, managing the servers on behalf of their customers. If a system or app is not being used, no computing resources are consumed. Serverless runs on specific host platforms, most of which are based in the public cloud (like AWS Lambda or Azure Functions). Serverless Framework is an open source software development environment for serverless deployment of developed systems in the cloud. For example, for developing apps with the Python programming language on Amazon Web Services, Serverless Framework creates a self-contained Python environment. In summary "serverless computing is an execution architecture in which application code is run on demand. From the user's perspective, the only work necessary to run the code is to upload it and trigger when it should execute" (Ramanathan, 2019, para. 7).

In contrast "containers" can run on any modern Linux server, as well as certain versions of Windows. They allow the end-user to deploy individual applications inside portable, isolated environments. Containers share system resources with the host server, and enable frictionless application deployment.

However, the host server must support the appropriate container runtime for deployment of containerized applications, this allowing the user to move such applications between hosts if required. There is no cost to container deployment if set up by the end-user, whereas there are fees to pay to cloud providers for the resources required for running serverless.

In the context of cloud-based analytics, Freshservice (n.d.) cites the case example of the University of Aberdeen, UK, where cloud computing provided access to powerful new tools for the university's incident reporting. The university has circa 18,000 staff and students, including an IT team of 180 members working across four divisions, who had been supporting incidents and service requests using a legacy tool implemented in 2009. "A lot of the processes involving incident management were manual, which increased their average resolution times and posed a challenge to their service delivery aspirations" (p.1). To improve customer service and overall efficiencies, the university moved to an ITIL-aligned, cloud-based, device-agnostic service desk, which allowed students and staff to raise tickets and access the new portal from a range of devices. "By pairing the portal with solution articles, the IT team has quietly started on its path to grow its portal usage and promote self-service" (p.2).

On the downside, several universities have reported suffering cyber-attacks following the adoption of cloud services. In 2021, the University of Hertfordshire revealed that it had "fallen victim to a cyber-attack that had impact on all of its IT systems, including those in the cloud such as MS Teams, Canvas and Zoom" (Computing Daily Update, 2021, April 16). The attack evidently took down the university's email system, Wi-Fi network, and student record portal, and its cloud services, such as Office365, were disrupted as a result. Students were advised that all external emails coming into the university had been stopped as a precautionary measure, and therefore programme leaders, tutors or other university service personnel were not able to receive emails sent by students. Other UK universities suffering cyber-attacks in the recent past include the University of Northampton, the University of York, University of London, University of Leeds, University of Reading, Oxford Brookes University, Loughborough University and the University of Birmingham. Delta (2020) concluded that "the number of applications moving to the cloud has increased. The number of attacks targeting cloud infrastructure has increased correspondingly. Cloud security is in its infancy and harder to manage" (p.7), and the National Cyber Security Centre (2019) has advised universities to implement a "defence in depth" strategy, pinpointing "strict access controls" (para. 40) and "the design of a university's computer network" (para. 41) as being key issues in the defence of their systems and networks against malware and ransomware attacks.

In terms of the strategies for moving to the cloud, as early as 2010, Gartner published its "5 Rs" model for cloud migration, which identified five alternative strategies (Rehost, Refactor, Revise, Rebuild and Replace), which could be selected and combined, depending on objectives and technology characteristics. This classification has been developed further by other operators such as Amazon, who came up with a "6 Rs", and more recently, a "7 Rs" model (Table 2). In assessing these options, SA Technologies note the "need to come to the decision after careful analysis. This is because you are not deciding just on migration, but on optimization as well" (para.16).

In the context of the literature discussed above, this chapter addresses the following research questions (RQs):

RQ1. To what extent has BCU migrated its systems to the cloud and what have been the main benefits?
RQ2. What has been the impact on IT support roles and skills requirements?

Table 2. Seven common migration strategies for moving applications to the cloud.

Strategy	Objective	Example
Refactor/re-architect	Move an application and modify its architecture by taking full advantage of cloud-native features to improve agility, performance, and scalability. This typically involves porting the operating system and database.	Migrate your on-premises Oracle database to the Amazon Aurora PostgreSQL-Compatible Edition
Replatform (lift and reshape)	Move an application to the cloud, and introduce some level of optimization to take advantage of cloud capabilities.	Migrate your on-premises Oracle database to Amazon Relational Database Service (Amazon RDS) for Oracle in the AWS Cloud.
Repurchase (drop and shop)	Switch to a different product, typically by moving from a traditional license to a SaaS model.	Migrate your customer relationship management (CRM) system to Salesforce.com.
Rehost (lift and shift)	Move an application to the cloud without making any changes to take advantage of cloud capabilities.	Migrate your on-premises Oracle database to Oracle on an EC2 instance in the AWS Cloud.
Relocate (hypervisor-level lift and shift)	Move infrastructure to the cloud without purchasing new hardware, rewriting applications, or modifying your existing operations. This migration scenario is specific to VMware Cloud on AWS, which supports virtual machine (VM) compatibility and workload portability between your on-premises environment and AWS.	Relocate the hypervisor hosting your Oracle database to VMware Cloud on AWS.
Retain (revisit)	Keep applications in your source environment. These might include applications that require major refactoring, and you want to postpone that work until a later time, and legacy applications that you want to retain, because there's no business justification for migrating them.	
Retire	Decommission or remove applications that are no longer needed in your source environment.	

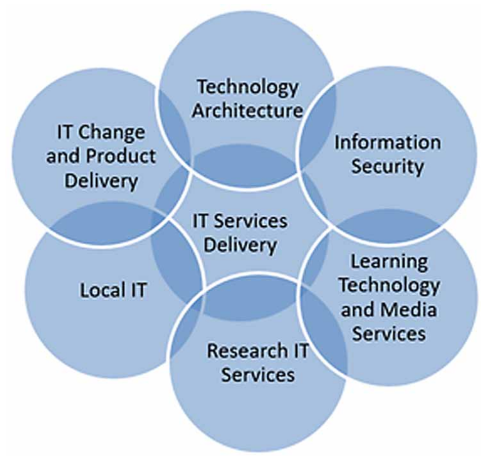
Source: AWS (n.d), paras. 1-2.

RESEARCH METHODOLOGY

This is a case study of cloud computing in a major university in the UK. Data collection was done using a questionnaire and interviews. The case study is a widely used research method within research into information systems and technology deployment. Bryman and Bell (2011) argue that the case study is particularly appropriate to be used in combination with a qualitative research method, allowing detailed and intensive research activity, usually in combination with an inductive approach as regards the relationship between theory and research. Saunders et al. (2018) argue that case studies are of particular value for explanatory or exploratory investigation, such as that pursued in this research.

The case study is of BCU (a pseudonym), which is a UK-based university with more than 8,000 staff and in excess of 25,000 students. It has a Technology Services Division (TSD – again, a pseudonym) which is the primary provider of IT services in the university. TSD provides and supports a wide range of services to support teaching, learning, research and administration. These include email, desktop services, networking, storage and collaboration, e-learning, training, IT support, application development, research IT, web development, telephony services, creative media services, IT hardware and software procurement, and IT security. The Division has six main areas of responsibility related to its core mission of IT Services Delivery (Figure 2), although management job roles are also aligned to different academic schools and functions.

Figure 2. Technology Services Division areas of responsibility



In-depth interviews were held with six members of TSD, all at management level. A preliminary questionnaire was first emailed out to participants, followed by the interviews. The participants were: Infrastructure Services Manager (henceforth referred to as P1); IT Services Manager - Applied Sciences (P2); Head of Learning & Media Applications (P3); Unified Communications & Collaboration Team Lead (P4); IT Services Manager - Pure Sciences (P5); and Head of IT, Medical Sciences (P6). The questionnaire comprised 15 questions on a range of aspects relating to cloud computing in the university, and the involvement and impact on IT services. Interviews via Teams were used to develop discussion and clarify issues. Quotations in the Findings section below are taken from the questionnaire and appended notes added in the interviews.

FINDINGS

The *systems migrated to the cloud* at BCU are shown in Table 3. The migration programme commenced in 2010 with Microsoft Office365, and has been managed by TSD, usually involving user testing. However, P5 commented that "in the case of Office365, it was a supplier led migration with the strategy of Microsoft clearly being to host applications and data in the cloud. Their cloud offering was far more capable and provided greater value." P3 stated that "as part of moving any of our services to the cloud, we carried out exhaustive pilot tests to ensure the migration process was both tried/tested and documented." Nevertheless, P4 observed that "no pilot was conducted for Zoom as several departments and individuals already had paid for subscriptions and we merely consolidated the individual licenses into an Enterprise agreement." P6 added "all migrations were led by TSD with input from the business – particularly in the testing stages."

The migration of the Microsoft Teams Calling telephony system indicates the complexity that migration projects can involve. The objective was to get over 1700 users from over 50 departments migrated to the cloud in two phases, spanning 2020 and 2021. The cloud-based Teams Calling system is a new telephony solution for the university, featuring audio or video calling via the chat function in Teams. In addition to the technical migration, other aspects of the project included provision of user guidance, phone recycling and procedures for emergency phones. In the first phase in 2020, 800 users were migrated, and phase two will complete by the end of 2021 for the remaining 900 users. Guidance and communication regarding the new audio device (headset), voicemail and how it works within the Teams environment, have been updated. An added dimension to the project has been the COVID-19 pandemic, which required all users to be able to make and receive all their telephone calls while working remotely.

Table 3. Systems migrated to cloud environment at BCU

System/Tool	Description	Date Delivery Service Deployment Model
Microsoft Office 365	Office productivity and communications suite	2010 SaaS Hybrid
Remedy Force	Used to log tickets (Incidents and Service Requests) from users of BCU systems; problem management	2013 SaaS Private
Oracle MyFinance	Financial business suite	2014 PaaS Private
Clinical Trials system	Collecting data for clinical trials	2016 PaaS Private
Access system	Used for identity and access management	2017 PaaS Private
Oracle MyHR	Human resources management business suite	2019 PaaS Private
Drupal	Content management system	2019 SaaS Private
Moodle	An online learning environment for creating and managing courses. Contains many thematic and functional areas - Blackboard Collaboration, Lecturecast, My Feedback, MyResearch.	2020 SaaS Hybrid
Microsoft Teams Calling (telephony system)	Phone system	2020/1 SaaS Hybrid
Zoom	Virtual, online, teaching and meetings environment	2020 SaaS Hybrid
Research and Library applications	Support the full research life cycle, including safe data storage, data analysis, research management and high-performance computing.	2020 SaaS Private
SITS package	Student records system	On-Prem
ULPC Stage server	Research data storage service (users record their research data here)	On-Prem
Data Safe Haven	A secure data storage area, certified to the ISO27001 information security standard and conforming to NHS Digital's Information Governance Toolkit.	On-Prem

The migration of systems to the cloud was motivated by *a number of interrelated issues*. P2 stated that it was "for improved efficiencies, scalability and, to some extent, to remove commodity services and focus on value add", and P2 added "resilience – to have fail safe options via a secondary datacentre, so it is easy to replicate cloud-based systems; cost – cost saving on estate and on a dedicated datacentre; and scalability – we can scale the hardware quickly with little down time." P3 emphasised that a key issue was "to do with elasticity and expansion - on-premises did not allow us to increase performance and the number of simultaneous connections. In today's environment, where the majority of teaching and learning is online, we need to provide fast, consistent and effective access to all our systems for everyone, anytime, anywhere." As regards specific systems migrations, P4 provided some detail: "ageing legacy phone systems, hosted over many sites, were no longer 'in support', as products had become 'end of life' several years earlier, and there was a growing need to provide a unified communications approach. The Microsoft Phone system was seen as a natural alternative and made use of our existing investment in Office365." P4 added, "the Teams Calling project was part of an overall strategic review of BCU's telephony system, and we engaged with a partner to provide the design and build of the solution, and maximise the newest emerging technologies such as SIP telephony. Although BCU has the main phone system elements based in the cloud hosted within Office365, we made a conscious decision to maintain critical hardware for telephony breakout on premise." Both Microsoft Teams and Zoom are used via the cloud for different purposes. P5 explained: "the fact that Microsoft Teams allows communication and collaboration made the exercise a 'no brainer'. With Zoom, the business case was to provide an online teaching environment and, at the time, Microsoft Teams had limitations that Zoom didn't – this has since been leveraged to provide an online training and online classroom environment (using Zoom)."

P6 summarised the overall rationale thus: "the main reason for migrating these services was to improve reliability, reduce the burden on on-premise resources, and allow for scalability. In the case of email, there was an additional drive from the Vice-Chancellor to have a single overarching communication tool, and to remove all departmental email servers. In the case of video conferencing, there were a number of physical video conferencing suites around campus, but these were hardly used. The addition of a cloud service for all users has made a huge difference – particularly since most staff are now working remotely. For the virtual infrastructure, this is work in progress, and is bringing a new range of self-service products to TSD teams – and eventually, to the customer directly. In all cases, reliability, functionality and access has improved considerably."

In terms of the *impact on staff and student users*, P5 observed that, as regards Office365, "I think users would have noticed little difference initially with email, but the addition of ever more features to the Office365 suite has delivered considerable improvements. Capacity is now offered in Office applications, which internal (on premises) systems could never support for both storage and performance." As regards Moodle, the migration "allowed BCU to scale up capacity in response to the increased need for online learning during the COVID-19 pandemic." P5 added "Drupal now provides a better experience for students internationally, as it caches content around the world, which can be delivered more efficiently in places like China;" and "we have implemented a number of SaaS platforms by either replacing old internally hosted systems or providing new capabilities. This has led to an increase in the number and variety of systems available to users." P2 noted that in the cloud, "web-based systems are so easy to access around multiple locations, with no additional overhead to install them. Overall performance is good, but reliant on good internet speeds." P6 concluded that for students and staff, the overall IT provision was "generally, much better. The ubiquitous nature of cloud services and the platform agnostic delivery model means that students are able to access them from anywhere with a network connection, at any time of day and from any device. There are no restrictions based on college closure, maintenance windows or internal infrastructure incidents. The ability of cloud services to deal with bursts in activity has meant that services have performed well even under heavy load (for example, Moodle Lecturecast)." Migration of user data to the cloud was managed by TSD staff in conjunction with cloud providers. For Zoom, for example, where staff and students had already set up their own accounts and associated data, P4 noted "we worked with them (the cloud provider) to build a process to easily migrate users' data from their personal accounts to BCU managed ones. For Teams Calling, users' data is migrated as and when we migrate the user." P6 added that he was "involved with the migration of mail data during the move to Office365. This was achieved by batch scripts running against the mailboxes of the individual user accounts, and there were no major issues."

Regarding the *overall plan and strategy for cloud migration,* P1 stated "there is a strategic plan to move to public cloud, with hybrid capability", and P5 noted "there is a 'cloud first' policy at BCU". P6 confirmed that "there is a general shift in TSD policy to consider moving as many services as possible to the cloud. In order to achieve the vision of 'world class IT provision', the university will always be looking to adopt best-of-breed solutions, which will invariably be predominantly cloud based." In terms of which delivery model is used for cloud services, P3 stated "the university uses both public and private cloud providers" and P5 reported that "Azure and AWS are the main providers for hosting TSD systems. We also use specialist providers in some areas for sensitive data used in research." P4 added "we have a range of on premises systems and utilise products from Azure, Amazon Web Services and hosted 3rd parties." P6 summarised the situation thus: "at present the university follows a hybrid strategy. There are many systems which will need to remain on premise for the foreseeable future (e.g., Data Safe Haven), but there are instances where cloud providers are being used to span services over internal and external infrastructure. Data storage, for example, now consists of hardware based in the two BCU datacentres, but also with cloud providers such as AWS and Google." P4 observed, "Microsoft Teams and Calling are used by staff as their phone system to make and receive calls, especially now that everyone is working remotely. This is an ideal opportunity to leverage the cloud based 'work from anywhere' system. The system is used by departments across the university from HR and Finance to academic departments. A future plan to implement a cloud-based contact centre will further leverage this." In terms of the seven migration strategies put forward by AWS (Table 2), these have been used in combination at BCU. In the main, however, the university has pursued a replatforming approach, through which some applications have been upgraded or optimised, by taking advantage of new capabilities available in the cloud.

Security, data protection and adherence to GDPR were highlighted as key issues requiring management focus. P1 stated that "verifying user identity is more crucial as the traditional security boundaries have shifted and are not just based on protecting a central facility; this means the focus of IT security is now on multiple fronts, and requires new ways of identifying and protecting malicious actors. GDPR policy doesn't necessarily change, but the methods to adhere to it evolve with the introduction of new platforms." P6 added that "a full risk assessment is carried out before any cloud supplier is engaged, and security is a major component of the contract…. GDPR policy applies to the way data is processed, which is the same for ALL services, whether they are in the cloud or on premise; so apart from ensuring that cloud data is located within the European Union, there are no additional implications for cloud services, other than the fact security is now a shared concern between university and service provider. As such, both parties have to agree what the threats are, and who is responsible for mitigating them." P3 confirmed, "all of the cloud providers that the university employs ensure data is held in Europe, and are ISO 27001 compliant, and follow the ISO/IEC 27002 code of practice." P5 raised the issue of location of data in the European Union vs in the US: "for the most part, this is a contractual consideration with specific costs and risks being offloaded to a supplier, and then covered in a contract. In many cases, this will be an agreement with a 3rd party SaaS supplier, who will then host on the cloud. I have found that most suppliers are able to provide details of their hosting arrangements with cloud suppliers to satisfy our requirements. Where data is hosted in different jurisdictions (the US, for example) particular care needs to be taken over legal protections for data." P6 also noted that the university's use of DropBox was "less of an enterprise strategy, and more of a GDPR requirement to secure the accounts of DropBox users who have signed up with BCU email addresses."

Backup and recovery procedures have been impacted to some degree, as data and systems have moved to the cloud. P6 confirmed that "less resource is required by the university in terms of storage space for backup, and staff resource to run and maintain the backup service. Cloud backup is by its nature 'offsite', so recovery to any new location is possible and service could be maintained – particularly in cases where onsite data centres are out of action. The downside is that longer backup retention policies may incur costs with cloud suppliers that have their own shorter backup windows. Added to this, with services that now effectively have shared control, the university is reliant on the supplier to react swiftly in cases where recovery is necessary, and whilst the terms may be clear in the contract, the university does not have the physical access to be able to intervene if suppliers do not fulfil their obligations." P3 observed "all of the cloud providers employed by the university provide a detailed backup and restore policy, either as a 'live to live' configuration or as 'cold storage'. Nevertheless, the cost of ownership is less than having the service run on-premises."

The *maintenance and upgrade process and procedures* for tools and systems have had to adapt to cloud provision. P1 noted that "generally it is vendor led, with some scope to manage the release cycle ourselves. But the general approach is that we need to understand the maintenance process of the vendor and conform to it." This was reinforced by P3: "all upgrades and maintenance are carried out by the vendor, and are incorporated in the pricing model," and P5 stated that "with SaaS systems, this forms part of the service, and therefore needs to be considered when contracts are agreed, and Service Level Agreements are put in place. Generally, this is less flexible than internally hosted systems; sometimes there is no choice over the application version being used; other times, you are restricted to staying within a specific range of versions."

The overall *impact on the support process and role development* has, as noted by P5, involved a number of aspects, "ranging from the renaming of teams, to the creation of specific cloud focused roles and creation of new services and teams." More specifically, P5 added "there are changes in a number of teams supporting backend systems. In areas where services have been consolidated around a suite of products (Office365, for example), support and services teams work much more closely together. There are also planned changes in 2nd line support to focus on smaller SaaS applications that support more specialised business activities, such as clinical trials and laboratory management. We are also supporting the creation of bespoke services built on user facing platforms, such as SharePoint using automation and integration workflow. This is something new for the organisation and sits somewhere between the previous support offerings of platform only and a managed service."

P1 noted that, in relation to Office365, "support is mostly about identity and ensuring users have accounts and access", but that "previously, support also involved maintaining servers, applications and databases, and …. required systems administration roles, but these are now supported by Identity and Access teams." P5 noted with "Office365 now running email, teams, SharePoint, telephony etc., it makes these services much more interdependent. Platform specific skills and understanding, along with a wider knowledge of the other activities that happen within the platform, are required." P6 also noted the problems with Office365, where "new tools are often introduced to the customers at the same time as the support staff," meaning that "support is very fragmented – often the 1st line support teams are not able to assist beyond the standard applications (Outlook/ Word/ Excel etc.)."

More generally, P5 observed that “the administrative tasks moved away from the technical teams to be done by super users. Fewer traditional skills are required such as programming, database design, and infrastructure management”, and that support of the SaaS platform is “more focused on experimental design and fast delivery as the SaaS platform does not require build, only configuration.” As regards virtual infrastructure (virtual machines, storage in the cloud), P6 observed “technical staff have expanded their expertise into cloud services as well as on premise storage. Customer support doesn’t alter much - storage is still presented as storage, and virtual machines are still virtual machines. The fact they may now be delivered via both the cloud and the BCU data centre is obscured as far as the customer is concerned, and the support route is the same.”

Such significant change in the support process has required appropriate *training and skills development.* P4 noted “we have sessions run, online support sites and staff have access to LinkedIn learning.” P6 provided an overview as follows: “some new competencies around cloud services have required additional training: email administrators now need to understand Microsoft Office365 administration, Azure and MS Security. Additionally, support staff have had to learn Teams administration. Storage and architecture administrators have had to follow training programmes for Amazon Web Services. Additionally, 1st, 2nd and 3rd line support staff have required training in the client services introduced by the cloud providers, particularly around Office365, such as Power Automate, SharePoint administration, and the ever-increasing number of apps being packaged into the Office365 suite.” As regards other systems and tools, P6 noted that moving RemedyForce to the cloud meant “a relatively large learning curve for support staff to shift to the new service, though the basic incident management process remained as before.” Similarly, for cloud based virtual teaching and meetings tools, there was “a significant new skills requirement for the staff supporting Teams (and more recently, Zoom). From a customer perspective, these were two new tools to learn. In the case of Teams – everyone had to get up to speed with it, whereas before only a small number of customers would have been teleconferencing via Skype.”

DISCUSSION

There are a number of key issues that warrant further discussion and consideration. Firstly, what emerges from the review of literature and the findings from the TSD staff is the sheer *complexity of managing cloud migration* and its on-going support and maintenance, despite the claims of increased simplicity put forward by the service providers. There are a number of delivery service options and deployment models that can be used in parallel, and a range of possible approaches, which in combination require a step change in service management and delivery. A recent IDC report (IDC, 2019) alludes to part of this challenge as “workload orchestration”, noting that “successful cloud migrations assess where operational workloads should reside based on location, characteristics, usage pattern, governance, and data requirements,” (p.17). This was evidenced at BCU, where, as part of their hybrid cloud strategy, some systems remain on premises for data security reasons, whilst cloud providers were being used to span services over internal and external infrastructures, with data storage on hardware in two BCU datacentres, but also with the cloud providers AWS and Google. The complexity involved in such infrastructure and data management may constitute a significant challenge for universities with fewer resources than BCU. Nevertheless, once achieved and in place, cloud-based services offer tangible benefits as evidenced at BCU, where the services managers interviewed stressed scalability, accessibility and response to short-term surges in demand as key benefits.

Secondly, it is evident that *security remains a major issue* in cloud computing for universities, and this requires additional resourcing, despite the efforts of cloud providers to build in aspects of confidentiality, availability, and integrity. At BCU, this was fully recognised, and security was a key element of contractual agreements with cloud providers. The location of university data in the cloud is one dimension of this, with the university requiring data to be held in Europe, where Information Security Management standards (ISO 27001) apply, rather than in the US, for example. At the same time, verifying user identity was highlighted as crucial, as the focus of IT security was now on "multiple fronts", and required new ways of identifying and protecting malicious actors. Trend Micro (2019) highlight the security implications of moving to the cloud and the overheads on IT support. They note "the data center is undergoing a tremendous transformation. Organizations are now moving their server workloads to the cloud, and even leveraging containers and serverless in their cloud-native application architectures. There are many advantages of hybrid cloud computing; however, it also comes with new risks and threats. Your organization must ensure compliance requirements are met, and that you have security across all of your workloads: physical servers, virtual, cloud, or container" (p.1). This is reiterated by Fortinet (2019), who emphasise the security implications of hybrid cloud from multiple vendors. They point out that "built-in security tools for the various cloud providers are unique and incompatible," and that "consistently managing risk across all clouds renders security operations, in a multi-cloud world, time-consuming and ineffective. In addition, the expanded attack surface means that organizations must protect themselves from risks originating from both the application programming interface (API) and the user interface (UI) of cloud platforms. And these risks can result not only from configuration and management errors, but also from the application elements themselves" (p.3). The report concludes "integration of the security controls of public cloud resources is one of the newest and most important priorities for securing the public cloud. Integration helps organizations protect data, prevent intrusions, fight advanced threats, and satisfy auditors" (p. 14).

Thirdly, cloud migration has required support staff to acquire new knowledge and skills and has been the catalyst for *a new culture of multi-skilling in the IT support environment*. At BCU, cloud migration required new skills for both first and second-line support teams, and new teams specialising in identity, access, and platform knowledge and management, have emerged. Pettey (2018) refers to these multi-skilled professionals as "versatilists" who "hold multiple roles, most of which are business focused rather than technology related" and noted that "40% of IT staff will be 'versatilists' by 2021" (para. 5). Pettey (2018) also suggested that this transition would start first in the infrastructure and operations support teams, then encompass the non-technical management roles, and in time impact on software development, project/program/portfolio management, and technology architecture. In this context, IT support teams will have "a key role to play in providing an organizational 'nerve center' that can quickly sense, respond to, and provision applications and infrastructures" (para.2).

Fourthly, and linked to the above issues, there is a need for a *top-down cloud migration strategy* that takes a holistic university perspective of the wide range of issues involved. Such a strategy needs to go beyond the scope of the 7Rs identified by AWS, which are more alternative approaches, rather than a strategy *per se*. It also needs to be "top-down", rather than "bottom-up" as differentiated by Earl (1989). This is a concern in some universities, where there is a history of departmental standalone initiatives in the acquisition and use of IT. Indeed, Elliott et al. (2016) noted that higher education institutions "showing progress toward enhanced digital capabilities are working in pockets of change rather than at broader levels within the institution," and that "most service providers engage at the departmental level and are often hampered by narrow scopes and tight budgets" (p.4). With so many variables and options involved, a bottom-up approach is unlikely to be successful, and may prove costly and counter-productive in the mid to long term. A cross-university strategy that encompasses policy issues regarding cloud providers, products and standards is needed. A strategy for cloud migration and its on-going maintenance will be a central part of overall IT strategy, as cloud computing becomes increasingly more significant than on-premises computing. Such a strategy should also be cross-referenced with, and interwoven into, a wider digital transformation strategy for the university as a whole.

CONCLUSION

Hugh James, business director of consultancy firm Manifesto, recently observed that “historically higher education has been behind the curve of digital innovation uptake”, but that there was “cause for encouragement with pockets of the community demonstrating successful digital and innovation progression” (Manifesto, 2020, p.4). A central feature of this progress has been the migration to cloud services that most universities worldwide have embarked upon to some degree. At BCU, this entailed a carefully managed migration programme spanning more than a decade, with the majority of systems and services now provided via the cloud. As noted by interviewee P6, the main benefits have been “reliability, functionality and access” which have “improved considerably.” Notably, “the ubiquitous nature of cloud services” provides students with access from anywhere with a network connection, at any time of day and from any device. These benefits, however, are counter-balanced to some degree by less control on backup, recovery and upgrade processes, the procedures for which are embodied in contracts with the cloud providers; and, above all, on the increased exposure to cybercrime and the heightened focus on security issues.

The impact on IT support roles and skills requirements has been very significant at BCU, but phased in over a number of years, as part of a staged migration of systems to the cloud. As interviewee P5 noted, there are a number of different dimensions to this, from the “renaming of teams, to the creation of specific cloud focused roles and creation of new services and teams.” These include skills development in new areas such as “bespoke services built on user facing platforms, such as SharePoint using automation and integration workflow.” Overall, with increased interdependency of different teams, there has been a move to multi-skilling and flexibility. At the same time, some of the old job roles have changed or disappeared, with systems administration roles, for example, being subsumed within new Identity and Access teams, or moved into the user community to be done by super users. This is all part of the re-purposing of IT support to act as an organisational “nerve centre” as referred to by Pettey (2018).

The advent of the COVID-19 pandemic has brought further clarity to the potential and relevance of cloud services in higher education, and underlined the urgency for appropriate investment and change. Lowendahl et al. (2020) concluded “higher education is essentially an information industry with very high digital potential, yet its progress in digital is slow compared to most other industries. This exposes traditional higher education to a high risk of digital disruption” (p. 12). In this context, cloud migration is one element of a wider set of challenges and options that encompass the use of third-party cloud-based educational technology (EdTech) services for teaching content development, operation and distribution. As noted by Elliott et al. (2016) “the tipping point for institutional leaders – the point where taking action is critical – will occur when the inability to meet the digital expectations of today’s education customers impacts the quantity and quality of students enrolling in their universities……once this happens, they will be playing catch-up with leaders who have been willing to make bold investments in strategy development, contemporary technologies ….. and partnerships with service providers" (pp.4-5). It is hoped this study of BCU will provide a useful case example of the key issues involved in taking the first steps in such a transition.

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KEY TERMS AND DEFINITIONS

Hybrid Cloud: Involves a combination of private and public infrastructures that are distinct but adhere to common standards that facilitate data and application portability between the two environments.

Hyperscaler: Very large corporations that dominate the cloud services industry, and which are now expanding their business operations into other areas, such as retailing and the automotive industry, using their strength in technology ownership and management. These companies include Google, Facebook, Microsoft, and Amazon.

Infrastructure-as-a-Service (IaaS): One of the three main service delivery models, the cloud provider manages just the servers, storage, networking, and virtual machines in the cloud.

Platform-as-a-Service (PaaS): In addition to the services made available in IaaS, the provider also makes available a development environment that enables users to create custom-built applications, but applications and data remain managed by the end-user.

Private Cloud: One of the three main deployment models for cloud computing. The cloud infrastructure is for the exclusive use of one organization. It may exist either on-premises or off-premises.

Public Cloud: The cloud infrastructure exists on the premises of the cloud provider and can be used by any subscriber. However, it may be owned and operated by other organisations.

Software-as-a-Service (SaaS): Applications are run on the provider's cloud service, and both data and applications are managed by the provider. There is no development environment for the users. This is the most extreme option for cloud computing, being at the other end of the spectrum from on-premises ("on-prem") computing, where everything is run and managed in-house.